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CONTRIBUTIONS TO THE LIFE-HISTORIES OF PLANTS. NO. VI.

BY THOMAS MEEHAN.

ON THE CAUSES AFFECTING VARIATIONS IN LINARIA VULGARIS.

Few subjects more deserve the attention of thoughtful students of biology than the extent of variation aside from the conditions of environment. Instructive papers bearing on evolution are continually appearing, the full value of which is impaired by the passing suspicion that the authors have not fully perceived how great is the innate power to vary, independent of any external influences. That environment or surrounding circumstances have considerable influence on the production of new forms may surely be admitted without detriment to a profound belief that very much more is due to a tendency to change implanted in the organism, the laws governing which the keenest scrutiny has hitherto been baffled in the effort to detect. It is possibly from this confession of ignorance, that the advocates of change by environment have gained so much strength. He who has something tangible to please us, has more power than he who has to confess that he does not know. Those of us who would not have conceded as much to environment as is frequently claimed for it, can only insist that change is evidently going on in order, and evidently in accordance with a regular plan,—while if all claimed for environment were conceded to be sound, it would subject change to the mere chapter of accidents; and the harmony, and the exact dependence of one thing on another, which everywhere prevails, could scarcely exist.

It has been my fortune to have to show that in many cases where variations have been charged to crossing by foreign pollen, or by other " conditions of environment," it was extremely probable that the sole actor in the work was this unknown law of change; while I have shown in many monotypic species, or in species removed from all possibility of intercrossing with other species, that the variations are quite as wide as if there had been full opportunity for the supposed laws of environment to operate.

Here I will call attention to the interesting variations any one may find in an hour's walk among *Linaria vulgaris,* the common yellow toad-flax, in any district where the conditions are absolutely identical, and the plant tolerably abundant. Let one gather in the walk any specimen that seems to be slightly different from another, and he will be amazed on comparing the handful, to note how great the difference. The foliage does not vary much, but some of the most divergent flowers might pardonably be referred to distinct species, did not the intermediate forms show that they were all of one family. There are variations in color and in form. In color, some are pale straw, and others deep yellow, while the palate varies from deep orange to the faintest possible tinge of yellow. At times nearly all the corolla, except the palate, is white instead of the normal tint, and again are forms in which only the backs of the two upper segments are white. But the most interesting variations are in the form of the lower lip. This is trilobed. Sometimes the lateral lobes are so broad as to overlap each other, when the central lobe seems hardly noticeable. At other times, they are so widely separated that the trilobed character is noticed at a glance. In some instances the central lobe is scarcely produced, in others it is large and broad, extending to the line of the lateral lobes.

What has environment had to do with these widely variant forms? The most diverse will often be found in proximity where no one could suggest any difference whatever in the surrounding conditions. It is an introduction from Europe, and has no close allies that any one could name as likely to influence its pollination. Indeed, if these were present, they would be inoperative as the plant is here, and probably everywhere, a close breeder, as I noted years ago. The pollen sacs burst before the corolla opens, scattering the fertilizing dust over its stigma which is evidently influenced thereby before the wind or insects have had any chance to operate. The flowers can gain no advantage from any outside agency, usual with those where insects have some opportunity to bring in foreign pollen before it is too late.

Aside from all this is the fact that the plants in any one given locality, but a few years ago sprang from possibly one, or at most a few progenitors, which, introduced by accident from Europe, escaped the cultivators destructive hoe, and then spread, through its progeny.

There seems no escape from the deduction that the plant derives from some pre-natal influence power to vary greatly, without any regard to the long periods of time sometimes called for, and wholly independent of external influences.

On the Self-Fertilizing Character of Compositæ.

Lepachys pinnata.—The proposition originally, I believe, presented by me, that all plants abundantly fertile are arranged for self-pollination, and are really self-fertilized receives its best illustration in Compositæ. It is rare that a floret capable of producing fertile akenes, proves barren. When I presented some years ago this natural order of plants as an illustration of this principle it was asserted by the late Professor Gray and others, that in many there were bi-lobed stigmas, the lobes being closed when the pistil pushed up through the pollen of the staminate column, and that the inner surface—the stigmatic surface—did not receive the flower's own pollen, but had to receive it from visiting insects, or it fell on each floret of some earlier opening flower. The very production of the ray florets, was regarded by these justly eminent men as to be compared to signal flags unfolded by the flower for the chief purpose of attracting insects. When it was shown that the flowers of composites invariably produced seeds, though fine netting excluded the insects usually supposed attractable by the "signal flags," namely thrips, found in so many flowers in abundance, were charged with the duty of cross fertilization, notwithstanding the proposition, well put by Mr. Darwin, that the fertilization of one flower by another on the same head was, practically, self-fertilization. It was left to me to show by easily tested observations on flowers having a marked contrast of color between the pollen and stigmatic surface, that the pollen tubes entered by the clefts in the closed bi-lobed stigmas, and that usually pollen grains on the closed lobes fell in on to the stigmatic surfaces when the expansion of the lobes took place.

The object of this brief chapter is to add to the list of these easily noted self-pollinating, and I may say, self-fertilizing species, *Lepachys pinnata* Gray. The long showy rays make magnificent "signal flags," but no one can see otherwise than that the large and showy orange pollen grains, get the chance to pollinate the brownish stigmas before any insect, not excepting thrips, can possibly have a chance to do the work.

Bidens frondosa.—In this plant we have an arrangement by which the visits of insects are prohibited. The retrorsely sharp barbed teeth of the akenia are longer than the florets, and insects could not rest on the heads without feet or wings getting entangled in these sharp barbs. It is assumed that the teeth have been produced in the barbed condition to provide ingeniously for the distribution of the seed. Certainly the barbed condition does materially aid in such distribution. And it might be contended that in the evolution of distributing agencies, the effort has been so vigorously successful as to interfere with the assumed effort in plants to avoid self-fertilization. But whether the arrangement is or is not, especially provided to insure self-fertilization, it is clear that this is the result. It cannot be said that *Bidens frondosa* has in any way suffered by ages of pure in-and-in breeding.

Aside from the seeming difficulties in the way of an insect's visit to the flowers through the protective presence of these barbed points, the author has for the past two years, taken frequent opportunities to note whether such visits are actually made, without seeing one instance. It is true bees and other honey-seeking and pollen-gathering insects usually continue at work on one particular species if at all abundant, neglecting for the time being, others equally deserving their attention. It does not follow that bees continually avoid a flower they may seem to be neglecting to-day. It is, however, scarcely probable that the author should not sometimes find bees visiting these flowers, if there was any disposition to do so. On this day, Oct. 4th, very few flowers are left, the floral season having nearly terminated. The occupants of my neighbor's large bee-farm are busy trying to profit by these last blooms of the season. A large tract under my observation is densely covered with *Aster puniceus* L. and *A. puniceus vimineus* Gray, the common Mexican weed *Galinsoga parviflora* Cav., *Solidago ulmifolia* Muhl., and our *Bidens*. But though in some instances, especially in the case of the *Galinsoga*, the branches of *Bidens* intertwine with the others, the bees neglect them.

We may be justified in assuming that *Bidens frondosa* L. is not only so arranged in the structure of its florets that foreign pollen cannot be effective, but that, through the structure and position of the barbed teeth of the akenia, insect visits do not occur, and are rendered impracticable.

ON THE STRUCTURE OF THE FLOWERS IN DIPTERACANTHUS MACRANTHUS.

Dipteracanthus macranthus (Nees), in gardens under the name of *Ruellia macrantha* (Mart.), should, as a true member of the genus, have the limb of the corolla "sub-equal." Two of the five divisions are, however, smaller than the others; and, with a little more effort, might have been bi-labiate. The fact is interesting as suggesting some other consideration.

In many bi-labiate acanths, the two smaller lobes form the upper portion of the flower; the three larger, the lower. In this species, and the species of some allied genera, the pair of smaller lobes form the lower portion of the flower. Examining the buds in an early stage, it may be noted that they are indifferently turned,—some having these smaller lobes uppermost, and some with them beneath. These buds, at first greenish, change to purplish eventually, and when they reach this stage, the tube twists in the case of those with the upturned smaller petals, while those in which they are lower from the first, do not twist. Thus in the end, by the twisting of the tube in one case, all the flowers eventually have the two smaller sections lowermost.

It may be stated as a broad proposition that it is so essential to the true character of this species that the smaller lobes should be lowermost, that when the accident of early formation turns them upside down, the flower will twist its tube to regain the position which we are compelled to regard as its natural one.

It is surely worth considering why it is so necessary that the flower should occupy a position which is exceptional among plants of the order, and to discover if possible, the mode by which the flower is brought to this exceptional position.

This very large flower affords good opportunities for studying the construction of its several parts. The slender tube is 1½ inches long, the stamens extend two inches beyond the tube, while the limb of the corolla is fully three inches. In many flowers the union of the primary parts out of which a monopetalous flower is theoretically composed is so thoroughly concealed that the superficial observer would not suspect the primary gamopetalous condition morphology teaches. Here, however, the strong veins of the primary structure remain, rendering it evident that the parts were really separate, and that the act of union was a subsequent event. We also see that though the stamens usually appear to grow out of, or to be borne by the corolla in Acanthaceous plants, in this species, though attached to the lower portion of the corolla tube, they are really a separate monadelphous set of four, become free from the tube eventually, and continuing for some distance into the limb of the flower, its monadelphous state.

We may pause here for a moment to reflect that a petal, transformed from a leaf as it is, loses its vigor in proportion to the completeness of that transformation. A true leaf will live say three or four months, but when transformed as a petal it will die in that many days. When the separate parts in the same flower undergo different degrees of transformation, the parts retaining most of the original leaf vigor will out-grow and control the least vigorous.

Returning now to *Dipteracanthus* we see that the two lower segments have lost, in a great measure, the venation characteristic of the three upper ones. The power to act as leaves would act, is more strongly retained by the three upper than the two lower. They have had no difficulty in retaining the upper position—or as we generally say, though possibly inaccurately—the most favored position towards the light. We can therefore explain that in the process of transformation from primary leaves to petals, two were arrested earlier than the others. These, continuing a little longer their growth as leaves, were able to get the *upper hand* of the others, which were transformed earlier. We may now see pretty clearly *how* the flowers of the *Dipteracanthus macranthus* are constructed on this peculiar plan—can we as readily tell *why?*

Let us examine first from the standpoint of the speculations so prevalent regarding the relations between winged creatures (insects and birds) and flowers. The flowers, like those of numerous Acanthaceous plants, secrete an almost fabulous amount of nectar as the blossoms are about to fade. The large open limb of the bright purple corolla must be very attractive to humming birds, or to those long-tongued insects capable of reaching through a tube an inch and a half in length. Unfortunately the stamens are so compactly arranged around the style, that one can scarcely conceive of any creature's tongue getting down to the sweets; and when, as in half the flowers, we find the tube twisted as a cork screw, we must see that nature has had no thought at all for arrangements to accommodate the winged visitors.

If we adopt the views I have advanced in many papers, and which I believe I may claim as essentially my own, that in any system of nature where some creatures are dependent on others, and recognition of these separate classes severally by others an essential condition of existence, variations in nature must, in a great measure, have been provided for the mere sake of recognition. In the "struggle for life" some means must exist by which to distinguish friends from foes, if for no other reason. It is not necessary, therefore, with my views of the interdependence of things, to look into every variation or peculiarity of behaviour, as related to a supposed benefit to the plant in the struggle for life. I doubt whether there is any special reason for the behaviour which results in this beautiful species, except the necessity for infinitive variation.

As I remember, other Acanths present similar conditions to that described in this species, but I have confined this chapter to it through having it now before me. It was to teach the lesson as much as to describe the interesting condition of things.

AERIAL ROOTS IN VITIS VULPINA.

Some one sent to Professor Asa Gray, in 1863, some aerial roots of the Scuppernong grape, and received a reply from him that the interesting fact had not been before noted. He advised the collector to send a note of the fact to the author of this paper, which, with Dr Gray's letter, was done. The author could only say that it was a fact as new to him as to Professor Gray, though it was not unusual to see aerial roots from the main stems of the European grape when under hot-house culture.

The subject seems not to have again attracted attention. Recently a coil of these roots brought from the South and presented to the Academy by Joseph Walton, of Woodbury, New Jersey, showed that these aerial roots were not wholly annual as in the hot-house grapes referred to, but were three years old at least. They were several feet in length, and forked at the apex of each annual growth. Thus a three-year old root consisted of six branchlets from the original rootlet. This is interesting from the fact that in the more familiar cases the aerial rootlets are annual, to wit: in the Poison Vine, in *Ampelopsis*, and English Ivy. These well-known rootlets will, however, become permanent when occasionally finding rich material to penetrate. Josiah Nicholson, a correspondent of Joseph Walton, residing in the vicinity of the grape vines, states that many of these roots die annually, and he knows of none that have gone down from any distance and reached the earth as the Banyan and Mangrove do. An acquaintance of Josiah Nicholson's says that when a vine with these rootlets falls to the ground, they will enter the earth, but not by their tips, but by new rootlets from the surface of the older ones.

There will naturally be inquiry as to the function of these aerial roots. The question has never been answered by the growers of the grape under glass. The grape vine has never been found to be the better or the worse for their production. In the case of these wild vines, the rootlets not reaching the ground, are probably functionless. It is conceded that in plants, as in animals, habits once contracted become hereditary and continue long after the causes which produced them have ceased to exist. If the ancestors of the grape were geotropic, the stems, rhizome-like, creeping along the ground and rooting from the nodes, before the tendril-climbing habit was formed, we could say with some certainty that the aerial rooting habit now occasionally seen, is the remains of the early habit not yet wholly obliterated. It is indeed probable that the ancestors of the grape were rhizomatous or creeping, and that the present stem of the grape vine, now elevated by the tendril-climbing habit, in former times was supported by the earth alone.

ADDITIONAL NOTE ON THE ORDER OF FLOWERING IN THE CATKINS OF WILLOWS.

At p. 267 of the Proceedings of the Academy for 1890, I noted the curious fact that in the male aments of willows the stamens develop from the center of the catkin first, and that growth follows upwards and downwards simultaneously from that point.

This season I have extended my observations to other species I had not before examined, with the same result. It is probably the rule with all willows.

I had not noticed the behaviour of the female aments till this season. It is well worth noting that this rule does not prevail in them, at least in three species, all I could examine. Here the stigmas appear mature simultaneously over the whole ament. No reason for this difference in character between the male and female aments suggests itself.

SELF-FERTILIZING FLOWERS.

A long list of flowers which cannot use their own pollen has been placed on record, as well as of plants that depend on insects or outside agencies for the use of their own pollen. There are also flowers which, capable of using their own pollen in a late stage of anthesis, are so constructed, as regards the relative maturity of stamens or pistils, that they may be fertilized by foreign pollen before being able to use their own. The records of all these make important material for philosophical strictures. The author of this paper has performed his own share in this work.

It is a continual thought with him, however, that the facts which bear on self-fertilization deserve equal prominence. It is a line in which there seems to be few workers. The following additions to others already recorded are offered, not because cases of absolute self-fertilization are unfrequent, but because a study of these particular instances developed other facts of interest in the study of plant life as well worth recording as the mere fact that they are self-fertilizers.

Symplocarpus fœtidus.—So much has been said of the relations between insects and flowers,—even a structure so peculiarly arranged as the skunk cabbage, *Symplocarpus fœtidus,* being claimed as an illustration of some close relation—that I devoted a half-day of the 22nd of February to a thorough examination of plants growing in the woods and swamps within a short distance of my residence in Germantown. I gained some facts in addition to those recorded in the chapter on this plant in my "Flowers and Ferns of the United States," vol. I, series 1., p. 57 et seq., 1878. It was there shown that the sexual character of the plant is variable, and that the hermaphrodite condition, as distinguishing the genus and its allies from their monœcious relatives, was a very slender line. A difference was noted in the relative maturity of stamens and pistils. Sometimes the stamens matured before the pistils, or, technically, the flowers would be proterandrous, at others the pistil matures days before the stamens, when the flowers are proterogenous. At that time I thought, as the result of the examination of a few flowers each season, that this difference was caused by the peculiarities of the season. The result of the examination of many flowers on the afternoon mentioned shows an almost equal number of both forms. Both thus existing at the same time and under the same conditions of temperature, the circumstances being in fact exactly the same, shows the difference to be of an innate character, and tending towards unisexuality. Indeed, so far as one may be justified by analogy in similar cases, and in the absence of an actual test by marking the plants and waiting for results, we may risk saying of the species that it is diœcious. If this be not the case, it is certainly tending towards diœcism.

In the one case the pistil pushes through the perianth, extending a full line beyond, and is capped by its beautiful head of stellate hair. No sign of the stamens is visible, though the pistil has evidently been protruded for several days, as it has lost the little globule of moisture that envelops it on its first appearance.

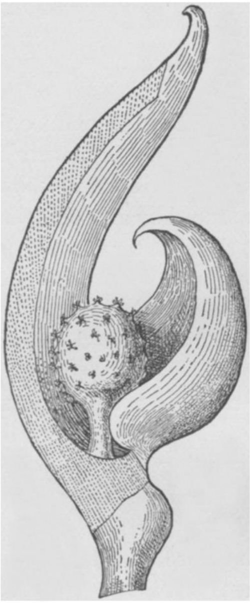
In the other case, the swelling anthers part the perianth segments, and exhibit the apex of the pistil nestling among the anthers. Finally the apex of the pistil, in company with one stamen, is protruded barely beyond where the pistil remains, but the stamen continues until the whole of the comparatively large anther extends beyond the perianth. The other three stamens follow the next day.

Certainly on one plant are flowers in which all the stamens are in advance of the pistils, and are very vigorous, while on other plants the pistil is in advance and comparatively strong, differences which in other species are associated with fertility or infertility, or, as we say, render the plants practically diœcious.

These conclusions are reached in face of the fact that they render the problem of fertilization still more difficult of solution. Although the dry pollen would indicate an anemophilous species, the manner in which the spathe is coiled around the spadix must render it next to impossible for the wind to be a material agent in carrying pollen to separate plants. As for insects, though I have seen a few flies on exceptionally warm spring days among the flowers, and other observers have noted similar insect visitors, these visits can be far from as general as we must demand before we can assign them any important part in a system of cross-fertilization. On the whole of the afternoon of Feb. 22nd, though they were the special object of the afternoon's search, the thermometer indicating 52° Fahr., no winged insect of any kind was seen. I cannot think that either insects or the wind have any material agency in fertilizing these flowers. As, however, I know that some plants in the vicinity of the examination bear an abundance of seed, the probability is that some individuals have flowers in which perfect hermaphroditism prevails, and that these are self-fertilizing.

The great variation in the color and form of the spathes and spadices of this plant has been often noticed. It is worthy of remark, however, that through all the changes, the striped and splashed character of the tints remains. The spathe may be either almost wholly yellowish-green, or purple, there will generally be striæ of one or the other color splashed over the surface.

In one case a flower was found with a double spathe, as is occasionally seen in the common garden Calla, *Richardia Africana.* The explanation given in the latter case is that the flower stem is but a consolidated mass of leaf-stalks, in which the blades of all but



the white spathe have been suppressed. There is no reason, therefore why these suppressed blades should not occasionally appear. The case of *Symplocarpus* shows the inflorescence to be also formed by the consolidation of several leaves, of which a second blade has been advanced though usually suppressed. This is the first case that I have heard of, but there is no reason why they should not be oftener found if looked for.

It may not be out of place to repeat what I have already noted in the chapter above cited that the flowers are odorless, the fœtid smell being given off only when the leaf or stem is broken. These facts were again confirmed on this occasion, showing the speculations that have been offered concerning the "carrion like odor" of the flowers as an attraction to carrion flies, to be, like many similar speculations, figments of overwrought enthusiasm.

Portulaca pilosa, L.—This is everywhere classed as an annual except by DeCandolle (Prodromus 3, p. 354) where it is classed as either annual or biennial. Among a collection of dried specimens brought by my wife from Punto Gorda, Florida, in the winter of 1887, I found a specimen with life and planted it in a flower pot, where it has continued to grow and flower annually. Now four years old, it seems likely to live for an indefinite period.

Its flowers open only, according to all authors before me, under bright sunshine, and then merely for a very brief period. De Candolle says it opens only between ten and twelve. Don, however, (Ed. of Miller, Vol. III, p. 74), notes that this is only true of days when the sun is out. Engelmann, " Plantæ Lindheimerianæ p. 155," observes that in bright sunshine it opens from 9 to 11 or 12, and at the same time notes that the neighboring *P. Gilliesii* Hook., originally from Chili, common in cultivation, opens from 8 or 9, to 2 or 3 P. M. in sunshine. My plant has never been set in bright sunshine, and thus the flowers which are produced abundantly and seed freely, have never opened.[1] They must of course, be arranged for self-pollination, or they could not seed so perfectly. Opening only in bright sunshine in their country, and no one flower opening twice, a large number of those growing in their natural places must of necessity also be close-fertilized.

The inquiry which these facts suggest is whether the chance for cross-fertilization could have been much of an object in nature in the arrangement for the opening of the flowers. It is a well known fact, that of the immense number of seeds produced by any one plant of any kind, but a very small number escape the chapter of accidents and reproduce a plant. If cross-fertilization were so desirable, it would seem that the flowers should have a better chance for effecting it than the brief period of daily opening, and limited, at this, to the few moments bright sunshine affords. As the facts stand, the greater proportion of seeds in this species are the product of close and not cross-fertilization.

To this fact we have to add that the expanding flowers do not seem to my mind to favor cross-pollination. The seed is most probably from close-fertilization in the expanded as well as in those which seed without expanding. I placed on record, Gardener's and Landsteward's Journal, 1845, that the stamens of *Portulaca grandiflora*—a mere form probably of *P. Gilliesii*—were irritable, and in 1878 (Proceedings of Ac. Nat. Sciences, 1878, p. 332) that the stamens of the common Purslane, are irritable also. Close observations have frequently been made on these flowers, because of irritability of a precisely similar character in *Opuntia* and other Cactaceæ. But in none of these observations has there been any suggestion of design or adaptation to cross-pollination by insect or other agency.

The leading object of this paper is not, however, to show the relation which the behaviour of these flowers bears to speculations on cross-fertilization, but to point out in how many particulars the character of some Portulacaceæ resembles some Cactaceæ.[2] A large number of the latter open only for a single day, and for a few hours, under sunshine, during that day. In my experience a large number never expand their petals, and the sexual organs are well protected from wind and from insects, but seed just as well. The bulk of the seed certainly, if not the whole probably, are the result of close-pollination. Again we have the resemblance in the irritable stamens, in the succulence, and many other characters. It is fair to assume that both families have had a close derivation, and if we would search for the object of nature in so limiting the duration and period of opening and yet with a resulting productiveness, we should probably have to look back in the past to some necessity common to both families, and which does not exist at the present time.

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[1] Aubrey H. Smith, Proc. Acad. Nat. Sci. Phila., 1867, p. 18, notes that the flowers on the introduced plants near Philadelphia, had "fruit imperfectly developed." The undeveloped flowers probably created this impression. I have little doubt but that later the seed would have been found abundant and perfect.

[2] See also paper on this subject, Proc. Ac. Nat. Sciences, Phila., 1883, p. 84.

Cuphea Zimpani.—Observing that with scarcely an exception the flowers of the annual species of *Cuphea* were fertile, I was led to look for the evidence of self-fertility in *C. Zimpani* in bloom in my garden, and found that it was so arranged that the reception of any pollen but its own was evidently impossible. An examination of the flower soon after the expansion of the limb would lead to the inference that it was arranged for cross-pollination. The two bearded stamens are abundantly polliniferous, while it is evident by the thick bearded mass below that the communication between stamen and pistil is completely cut off. Between the two large upper petals, however, the calyx forms a sort of sheath, down which an insect in search of honey, and not gifted with the tube-splitting habits of the humble-bee, would no doubt thrust its proboscis. It would be natural to suppose an insect thus examining a flower, would carry pollen to the next. But an examination of this sheath will show that the stigma cannot be reached in this way. That and the four other anthers remain coiled away in a nest of downy hair, which is at once the cradle and the grave of both. A more perfect adaptation for self-fertilization is seldom seen.

Daphne Cneorum.—Though I have seen this under cultivation for half a century, I have never known it to produce a seed. The flowers seem well arranged for self-pollination. The mouth of the tube is effectually closed by four anthers abundantly polliniferous, and the next day the second series of four below, also burst their sacs. The exposure of pollen is simultaneous with the expansion of the limb, and it seems next to impossible that foreign pollen should reach the stigma. The short style and stigma at the base of the tube seem perfect, but I have never been able to detect any pollen on the stigma. It is highly gelatinous and does not separate readily from the anther-cell. It looks as if it might be necessary for an insect to carry the pollen to the stigma, aiding in self-pollination as in *Yucca* and other plants. The tube is too long for the honey-bee, and the humble-bee slits the tube even before the flower opens, thus wholly avoiding contact with the stamens. It may be that in its native places self-pollination is aided by long-tongued lepidoptera, but this suggestion places the plant at a disadvantage in the "struggle for life" as it cannot travel as a self-fertilizer does.

> "He that fights, and runs away.
> May live to fight another day,"

does not apply to a plant, which cannot run.

Lopezia coronata.—That *Lopezia coronata* Andrews, a Mexican Onagraceæ common in cultivation, is a self-fertilizer, I am confident from the fact that every flower is fertile, and this is equally true of plants growing in green-houses where insects and currents of air are wholly excluded, as when growing in the open air. But I have been baffled in endeavoring to ascertain how the flowers own pollen, or the pollen of a neighboring flower, which, as is well shown by Mr. Darwin, is practically the same thing, reaches the stigma. To one who had not been assured of self-fertilization from the actual facts, the flowers would seem as perfectly arranged for cross-pollination as it is possible to be. In the early stages of the bud, before anthesis, the large single anther is introrse. It is sheathed by the blade of the petaloid stamen, and its own filament sheathes the style. At anthesis the connective twists, and the anther turns its back on the style. The anther cells burst at once, and some of the pollen undoubtedly falls on the apex of the style. The stamen soon recurves, until the face of the anther rests upon one of the sepals. At this time, however, the first day of opening, the apex can scarcely be called a stigma, for it is not till the second day that the globular, capitate, and capillate head, properly deserving of the name of stigma, is developed. Looking at the relative positions of stamen and stigma at this period, and when the latter might be regarded as in receptive condition, one might readily conclude it impossible that the flower could be individually self-pollinated. The next day the fading sepals and petals coil upwards and enfold the style and stigma. Whether the pollen which falls on the immature apex of the style at anthesis remains there till the stigma matures, or whether the pollen which has been scattered over the petals and sepals is brought up when the fading petals incurve may well be a question. Possibly, as before noted, its falls from the flower above.

Certainly pollination is not effected by insect agency, and the chief point of this chapter is to show how error may creep in by mere speculations on the arrangement of the parts. Here is a case where one might well believe the arrangements were nicely adapted to pollination by insect agency, when in fact the plant in some way not clear, but certainly, is self-fertile.